ISSN 2319 – 7757 EISSN 2319 – 7765

Indian Journal of

Engineering

Studies on drilling of wood based composite panels

Valarmathi TN[1*], Palanikumar K[2], Sekar S[3]

1. Research Scholar, Dept. of Mech. and Production Engg, Sathyabama University, Chennai, India
2. Principal, Sri Sai Ram Institute of Technology, Chennai, India
3. Professor, Dept of Mechnical Engineering, R.M.K.Engineering College, Kavaraipet, India

***Corresponding author:** Research Scholar, Sathyabama University, Chennai, India, Mail: valarmathi.tn@gmail.com, Mobile No: (+91)9445433963

Received 06 January; accepted 18 February; published online 01 March; printed 16 March 2013

ABSTRACT

Engineered wood or wood composites are used for domestic purposes and mainly in furniture industries. These composite wood products are manufactured by binding the wood with additives to form composite materials for specific applications. Wood composites made by the sanding process containing irregularities on the surface affect the surface quality of the end product. Drilling is most commonly used machining operation in wood composites. The surface quality achieved in the drilling process improves the performance and appearance of the end product. In this study, raw material type, board density and cutting parameters such as cutting speed, feed rate and spindle speed which influence the surface roughness and delamination damage in drilling of wood composites were analyzed. The drilling experiments are performed to find out the influence of drilling parameters on the surface roughness in drilling of wood composite panels.

Keywords: Wood composites, medium density fiberboard, particleboard, drilling, surface roughness

1. INTRODUCTION

Wood is a natural composite of cellulose fibers in a matrix of lignin. Composite materials are made up of two or more constituent materials having different properties such as physical, chemical, etc. to attain the combined advantages of each constituent material. The advantages of developing wood composites are to use smaller trees, waste wood from other processing, to remove defects, to create more uniform components, to develop composites that are stronger than the original solid wood, and to be able to make composites of different shapes (Berglund – Rowell, 2005). Composite materials are available as Fibre Reinforced Polymers include Wood, Carbon-Fibre Reinforced Plastics and Glass-Reinforced Plastics. Due to difference in strength, density and other properties of natural wood, an engineered wood is manufactured. Plywood, Particleboard (Low Density Fiberboard), Fiberboard (Medium Density Fiberboard), Hardboard (High Density Fiberboard), wood plastic composites, etc are some examples of an engineered wood. Particleboards are manufactured using low-grade woods under temperature and pressure. Particleboards are commonly used in making of doors, shelves and furniture's etc. MDF is generally manufactured in sheet form by the application of pressure. MDF material is widely used for many general and manufacturing applications because of its dimensional stability, high strength and superior machinability properties. Wood based panels are coated or plastic laminated to provide an excellent surfaces and to get good appearance. Machine-finished products are also available directly in the market. Coating eliminates the formaldehyde liberation, suppresses the absorption of moisture and water and improves the performance of panels. Type of coating material and quality of panel are very much important to achieve the better performance of fiberboards. Coating of panels mainly depends upon the surface roughness of the fiberboards. When the panels are laminated with melamine impregnated papers and a thin film, the surface characteristics of the substrate takes the vital role.

Composite materials: Composite materials are made up of two or more constituent materials having different properties such as physical, chemical, etc. to attain the combined advantages of each constituent material without changing the physical, chemical and mechanical properties of each material.

2. LITERATURE REVIEW

Surface irregularities present on the substrate may show through the overlay affect the quality of the product. The quality of the surface finish obtained by machining is greatly influenced by the characteristics of the fibers used, mechanism of chip formation and tool wear. Hence evaluation of surface roughness and surface stability is necessary to improve the quality of the final product. Surface roughness of wood panels was investigated by several authors to predict the influence of material properties, application of pressure, press type, etc. Nemli et al., (2005) investigated and found that raw material type, board density, pressure and shelling ratio have great influence on the surface roughness of Particleboard. Lin et al., (2006) investigated the machinability during turning of low and high-density MDF disc using different techniques, such as optical photography, Scanning Electron Microscopy (SEM) and quick-stop freezing. They found that the machining forces, power consumption and tool wear of low-density panels were lower than that of high-density panels but the machined surface of low-density panels has more protruding fibers and high-density panels generate a better surface finish. The surface roughness and deformation is more in low-density panels than the high-density panels. They concluded that the board density is the main control factor for the machinability characteristics and machinability can be improved by minimizing the unrefined fiber particles present in the wood panels. Davim et al., (2009) evaluated the surface roughness in milling the MDF panels using 8 mm of diameter end mils of grade K10 as a function of material removal rate (MRR) for different spindle speeds and observed that the surface roughness increases with increasing feed rate, and decreases as the spindle speed is increased. Hiziroglu et al., (2004) evaluated the surface characteristics of wood panels manufactured in Thailand. Surface roughness values of Particleboard and MDF specimens of were measured and found that surface roughness values of particleboard

Surface roughness: It is the quantified value of the quality of the machined surface after machining the workpiece using cutting tool.

Valarmathi et al.
Studies on drilling of wood based composite panels,
Indian journal of engineering, 2013, 2(5), 47-50,

Input control/Output response parameters

The set of input values used in any process is to find out the significant influence of each parameter on the output response values. It is uesd to determine the proper combination of input values to acquire the optimum output values by controlling the range of input values that is by increasing or decreasing or changing the input values.

samples were higher than the values of MDF samples. Hiziroglu – Kosonkorn, (2006) evaluated the surface characteristics of MDF panels of types A, B made from rubber-wood of 3mm thickness and types C, D made from eucalyptus of 6mm thickness manufactured in Thailand and found that panel type A had the roughest surface out of 4 types of panels due to distortion and non-uniform pressure application during the sanding process and panel type C had the smoothest surface along the sandmark. Also they have determined the density profiles of four samples from each type of panel and found that density profiles of samples of panel type C has higher densification on the surface layer as compared to panel types A and B. They have concluded that the better surface quality of panel type C is due to higher face densification. Manufacturing of wood products involves various machining operations includes drilling, milling, turning, etc to obtain the tequired size and shape. Among these drilling is the main and commonly employed machining operation in Particleboard and MDF. As compared to metals wood is softer, easier and faster to drill. No cutting fluid is used in wood drilling. Drills can tear out chips of wood around the top and bottom of the hole and it is the major problem in fine woodworking. During the drilling process the delamination damage is caused both at the entry and exit due to the drill thrust. The delamination in drilling reduces the performance and appearance of the end product. Therefore the control of the factors which influence the delamination tendency is essential. Davim, et al., (2008a) investigated the relationships and parametric interaction between the cutting speed and feed rate on the delamination factor at entry and exit of holes drilled in MDF panels of two kinds using Taguchi's L_9 mixed orthogonal array and Response Surface Methodology (RSM) modeling. Adequacy of the mathematical models were verified with ANOVA and concluded that delamination tendency can be reduced with higher cutting speeds. Davim et al., (2008b) investigated the effect of cutting parameters on delamination in drilling of 16mm thickness MDF panels using 5mm diameter cemented carbide drill of grade K20, at three different cutting speeds and feed rates. They found that the delamination factor decreases with the increase of cutting speed and increases with the feed rate for both materials but the scheme of delamination is different. Gaitonde et al., (2008a, 2008b) investigated the influence of machining conditions on delamination factor during drilling of MDF panel with K20 cemented carbide tool using Taguchi's quality loss function approach and optimized using Utility concept at various cutting speed and feed rate conditions. They developed the second order mathematical models using RSM and found that for a given drill diameter the delamination factor increases with increase in feed rate at lower cutting speeds. Valarmathi-Palanikumar, (2011) performed drilling experiments on laminated MDF panels to minimize the delamination and found that thrust force developed in drilling can be reduced with high spindle speed and low feed rate. Valarmathi et al., (2012, 2013) conducted drilling experiments on plain and laminated MDF panels using high speed steel and carbide drills of 10 mm diameter with three different point angles and developed a mathematical model to evaluate the effect of drilling parameters on thrust force. They found that low feed rate and high spindle speed are the preferable cutting conditions to reduce the thrust force in drilling of MDF panels. Valarmathi et al., (2013) performed drilling experiments on particle board panels using carbide twist drills of different point angles and developed a mathematical model to evaluate the effect of drilling parameters on thrust force. They observed that the dominant parameters which influences the thrust force developed in drilling are feed rate followed by point angle.

Cutting tool:
It is used to remove unwanted material from the workpiece (object) to obtain the required shape and size of the component part.

Table 1 Control parameters and their levels

S/N	Parameters	Levels		
		1	2	3
1.	Speed (N) rpm	1500	3000	4500
2.	Feed (f) mm/min	100	200	300
3.	Drill diameter(d)mm	6	8	10

3. EXPERIMENTAL DETAILS

The drilling experiments were conducted on particleboard wood composite pasnels of 12mm thickness with high speed steel (HSS) twist drills of three different diameters on CNC vertical machining center at dry condition. The CNC vertical machining center used for this experiment is shown in Figure 1. The experiments are planned using Taguchi's orthogonal array. The experiments were performed with three control factors at three levels based on Taghuchi design of experiments. The cutting parameters selected for the present investigation are spindle speed (N) rpm, feed rate (f) mm/min and drill diameter (d) mm. The control parameters and their levels used are given in Table 1. After drilling the wood composite panels the surface roughness values of the drilled holes are measured using surface roughness meter.

Drilling:
It is a machining process used to make circular holes in solid materials using a cutting tool called drill bit.

4. METHOD OF ANALYSIS

4.1. Taguchi Method

Taguchi methods are statistical methods developed by Genichi Taguchi to improve the quality of products. Taguchi methods emphasized quality through robust design, not quality through inspection. Taguchi method is a powerful tool to design optimization for quality. The Taguchi's method of experimental design provides a simple, efficient and systematic approach to determine optimal machining parameters. Taguchi recommends orthogonal arrays (OA) to study the entire parameter space with small number of experiments only. Also he recommends analyzing the mean response for each run in the inner array and suggests analyzing variation using an approximately chosen signal to noise ratio (S/N).

Table 2 Results of Analysis of variance for S/N ratios

S/N	Source	DF	Seq SS	Adj SS	Adj MS	F	P
1.	Spindle speed	2	14.815	14.815	7.407	47.21	0.000
2.	Feed rate	2	29.175	29.175	14.587	92.97	0.000
3.	Diameter	2	21.007	21.007	10.503	66.94	0.000
4.	Spindle speed*Feed rate	4	3.818	3.818	0.955	6.08	0.015
5.	Spindle speed*Diameter	4	1.257	1.257	0.314	2.00	0.187
6.	Feed rate*Diameter	4	1.230	1.230	0.308	1.96	0.194
7.	Residual Error	8	1.255	1.255	0.157		
	Total	26	72.558				

5. RESULTS AND DISCUSSION

Wood based composites are extensively used in furniture industries and building construction applications. Drilling is an important machining operation in the manufacturing of wood products. The quality of the drilled surface and the aesthetic appearance of the final product is reduced by the surface roughness. The cutting conditions and cutting parameters such as cutting speed and feed rate, drill diameter, drill point angle, etc plays a major role in achieving the desired surface qualities. Hence to improve the quality of surface finish of the final product it is necessary to study the influence of various control

Valarmathi et al.
Studies on drilling of wood based composite panels,
Indian journal of engineering, 2013, 2(5), 47-50,

Figure 1
CNC vertical machining center

parameters. In this study the drilling experiments were carried out using Taguchi design of experiments approach. Surface roughness values were measured using Talysurf. Taguchi optimization technique is used to find out the influence of cutting parameters on surface roughness. A linear model is developed using Taghuchi technique for analysis. The adequacy of the model is checked with analysis of variance (ANOVA) at 95% confidence level. The results of ANOVA for S/N ratios are given in Table 2. From ANOVA it is observed that the influence of feed rate is more on surface roughness followed by the diameter and spindle speed. Also it is observed that the interaction between the control parameters also have an effect on the surface roughness in drilling of wood composite panels. The interaction plots for S/N ratios for feed rate versus spindle speed, spindle speed versus feed rate, feed rate versus diameter, diameter versus feed rate, diameter versus spindle speed and spindle speed versus diameter are shown in Figure 2. From interaction plots it is observed that the surface roughness increased with the increase of feed rate, decreased with the increase of spindle speed and increased with the increase of diameter in drilling of wood composite panels. Hence it is concluded that the optimum cutting conditions for minimizing the surface roughness is low feed rate, smaller diameter and high spindle speed in drilling of wood composite panels.

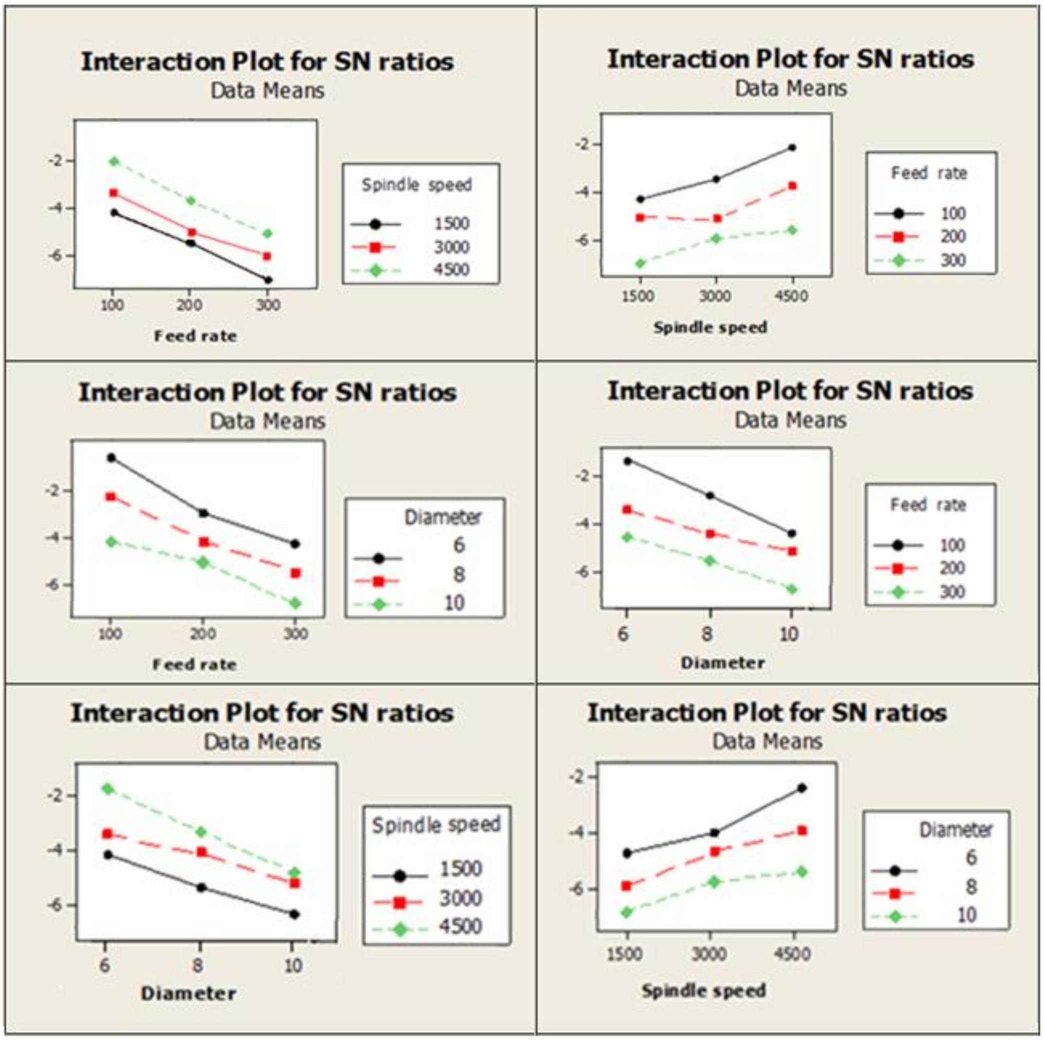

Figure 2
Interaction plots for S/N ratios

6. CONCLUSION

It is observed that the raw material type, panel density, pressure, shelling ratio, feed rates, spindle speeds and tool geometry such as tool diameter, point angle, etc., are the influencing factors in obtaining a better surface quality in the manufacturing and machining of composite materials. It is concluded that the optimum cutting conditions for minimizing the surface roughness is low feed rate, smaller diameter and high spindle speed in drilling of wood composite panels.

SUMMARY OF RESEARCH

The research trends in drilling characteristics of wood composites are presented. To model and optimize the drilling process parameters researchers have used new concepts like surface response methodology and Taguchi method. From this study it is observed that the cutting parameters and tool geometry are the important factors which minimize the drilling damages like the delamination at entry and exit of drilled holes and surface roughness of the drilled holes in wood composites.

FUTURE ISSUES

Further research work can be carried out using other modeling and optimization techniques such as fuzzy logic, neural network, genetic algorithm and grey relational analysis to improve the surface characteristics and to minimize the surface roughness in drilling. These research works can be effectively applied in industrial applications to select and use proper drilling conditions to improve the quality of drilling.

DISCLOSURE STATEMENT

There is no financial support for this research work from the funding agency.

REFERENCES

1. Berglund L, Rowell RM. Chapter 10, Wood composites-Handbook of wood chemistry and wood composites, *Forest Products Laboratory,* 2005, pp. 279-31

Valarmathi et al.
Studies on drilling of wood based composite panels,
Indian journal of engineering, 2013, 2(5), 47-50,

2. Davim JP, Clemente VC, Silva S. Drilling investigation of MDF (medium density fibreboard). *Journal of Materials Processing Technology*, 2008b, 203, 537–541
3. Davim JP, Clemente VC, Silva S. Surface roughness aspects in milling MDF (Medium Density Fibreboard). *Int J Adv Manuf Technol*, 2009, 40, 49–55
4. Davim JP, Gaitonde VN and Karnik SR. An investigative study of delamination in drilling of medium density fibreboard (MDF) using response surface models. *Int J Adv Manuf Technol*, 2008a, 37, 49–57
5. Gaitonde VN, Karnik SR, Davim JP. Prediction and minimization of delamination in drilling of medium-density fiberboard (MDF) using response surface methodology and Taguchi design. *Materials and Manufacturing Processes*, 2008a, 23, 377–384
6. Gaitonde VN, Karnik SR, Davim JP. Taguchi multiple-performance characteristics optimization in drilling of medium density fiberboard (MDF) to minimize delamination using utility concept. *Journal of Materials Processing Technology*, 2008b, 196, 73–78
7. Hiziroglu S, Jarusombuti S, Fueangvivat V. Surface roughness of wood composites manufactured in Thailand. *Building and Environment*, 2004, 39, 1359–1364
8. Hiziroglu S, Kosonkorn P. Evaluation of surface roughness of Thai medium density fiberboard (MDF). *Building and Environment*, 2006, 41, 527–533
9. Lin RJT, Houts JV, Bhattacharyya D. Machinability investigation of medium-density fibreboard. *Holzforschung*, 2006, 60, 71–76
10. Nemli G, Ozturk I, Aydin I. Some of the parameters influencing surface roughness of particleboard, *Building and Environment*, 2005, 40, 1337-1340
11. Valarmathi TN, Palanikumar K, Latha B. Measurement and analysis of thrust force in drilling of particle board (PB) composite panels. *Measurement*, 2013, 46, 1220-1230
12. Valarmathi TN, Palanikumar K, Sekar S. Modeling of thrust force in drilling of plain medium density fiberboard (MDF) composite panels using RSM. *Proceedia Engineering*, 2012, 38, 1828-1835
13. Valarmathi TN, Palanikumar K, Sekar S. Thrust force studies in drilling of medium density fiberboard panels. *Advanced Materials Research*, 2013, 622-623, 1285-1289
14. Valarmathi TN, Palanikumar K. Evaluation of thrust force in drilling of medium density fiberboard (MDF) panels. *National Journal on Advances in Building Sciences and Mechanics*, 2011, 2, 53-60